U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

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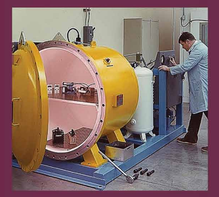
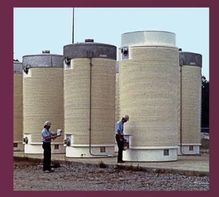
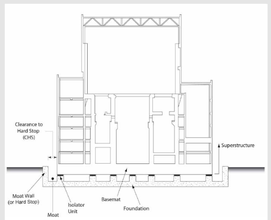



OFFICE OF NUCLEAR REGULATORY RESEARCH

Large-Scale Simulation of an Elastomeric Bearing Base-Isolated Structure Subjected to a Large Earthquake

Technology Overview

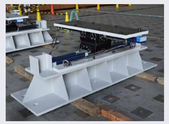
Seismic isolation (SI) systems are an important technology that has proven useful to reduce the accelerations and forces transmitted to the superstructure of the building during large earthquake shaking. SI has been used in the design and construction of nuclear facilities in France, South Africa, and Japan, and is being considered for use in nuclear facilities in the United States.



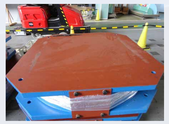
SI Nuclear Structure

The NRC's Seismic Research Program is studying this technology to provide the technical information necessary for NRC staff to review the use of SI-related technology.

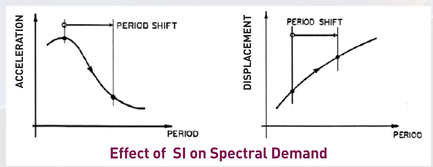
Base-Isolation Devices:


Cross linear (CL) bearing


Lead rubber (LR) bearing


Triple pendulum (TP) bearing

- change the fundamental vibration period of the superstructure to a significantly longer period
- reduce the accelerations and forces transmitted to the system and components in the superstructure by decoupling the movement of the superstructure from the foundation
- designed and tested to safely withstand the large horizontal deformations required to significantly decouple the ground motions from the isolated superstructure



Effect of SI on Spectral Demand

Test Overview

An NRC-supported program offered a full-scale demonstration of the effectiveness of base isolation in protecting a building structure.

Large-Scale Specimen

- 5-story steel moment frame building 10 x 12 x 16 meters tall
- 4 lead-rubber and 5 cross linear bearings
- 470 instrumentation channels with 1000Hz sampling rate
- 2 and 3D excitations with large vertical accelerations

Shake Table

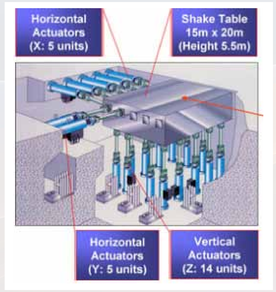
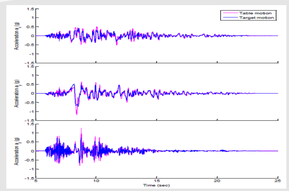


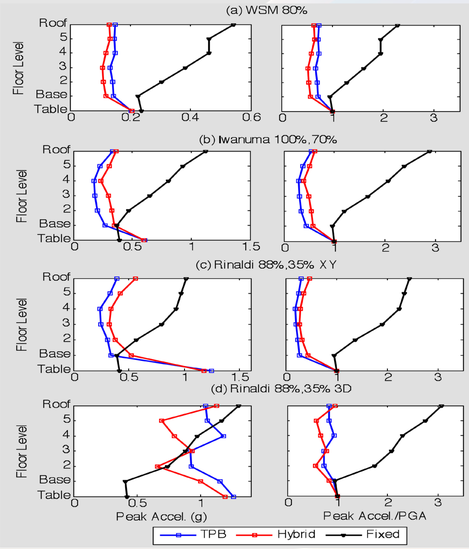
Table Size	20m x 15m	
Payload	12MN(1200tonf)	
Driving Type	Accumulator Charged/Electro-Hydraulic Servo Control	
Shaking Direction	X, Y - Horizontal	Z - Vertical
Max. Acceleration (at Max. Loading)	900cm/s²	1500cm/s²
Max. Velocity	200cm/s	70cm/s
Max. Displacement	±100cm	±70cm
Max. Allowable Moment	Overturning : 150MN-m	Yawing : 40MN-m

Simulated Ground Motions



Used 12 representative motions of nuclear sites scaled to reach the displacement limit of the system

Results Overview



WSM = Superstition Hills, Westmorland

Accelerations are absolute on the left graph and normalized by peak ground acceleration (PGA) on the right. The acceleration in the isolated building configurations was reduced to levels below PGA.

Documentation Under Development

- Overall test results and response characteristics will be documented in a an NRC technical report (NUREG/CR) report entitled, "Full Scale Earthquake Simulation of a Hybrid Lead Rubber Isolation System Designed for a Nuclear Facility."
- NUREG report entitled, "Technical Considerations for Seismic Isolation of Nuclear Facilities," will present a performance-based and risk-informed approach for SI that is consistent with NRC objectives.